The Integration of English Language Development & Inquiry Science into a Blended Lesson Design

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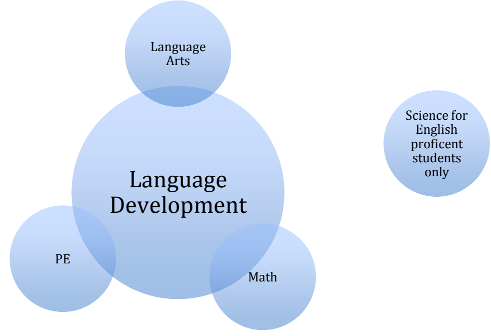
In its original design, the *Blended Inquiry/ELD Project* did not have language development as a goal or objective in its professional development (PD) plan. In fact, this project was described as an elementary science PD program in its initial funding proposal. Its primary goals were to deepen elementary teacher's science content knowledge and pedagogical skills in an effort to improve elementary students' science learning. Although the PD design included the use of strategies for making science content accessible to English learners (ELs), specific English language development content and pedagogy was not part of the original design. This paper will describe the unique sequence of events that led to a blended PD model and how our understanding about the relationship between language and inquiry science developed over the four years of the project.

The original motivation for an elementary science project was based on issues of access and equity. Like other districts, elementary science instruction had not received much support prior to the beginning of our program at our partner district, *Montebello Unified*. At the time the project began, there had been no attention given to the quality or frequency of science instruction and teachers had not been provided any systematic science-related professional development in recent history. Furthermore, district mandates regulated a substantial amount of instructional minutes be dedicated to subjects that were weighted heavily on state exams (i.e., English language arts and mathematics) and resulted in very few minutes left for other content areas. During this time, the district sites were organized with grades K-4 at the elementary and 5-8 at the middle schools. Since elementary science is tested in California at 5th grade, the elementary sites did not administer a science test. As a consequence, the students received very little, if any, instruction in science.

Figure 1: Initial State of Science Instruction at Elementary Sites



What science students did receive was sporadic and often limited to textbook reading. This was particularly true of ELs who, in addition to language arts and mathematics, received additional mandated instruction in ELD. It was not unusual for students in this district to reach 5th grade before they had access to any level of science instruction. EL's often waited until 8th grade before receiving any formal science instruction, leaving them years behind their native speaking counterparts with little hope of catching up prior to High School when college and career paths begin to take shape. The primary goal of our initial project design was to provide elementary teachers the knowledge and skills necessary to provide consistent quality science instruction in elementary sites (K-4) for all students.

Once funding was obtained, it became clear that finding instructional minutes for science was going to be nearly impossible. The solution was to make science the context for language development, thereby guaranteeing science 45 protected minutes each day. However, this solution required that the science instruction also successfully develop students' proficiency in a second language, something that was not part of the initial professional development design.

Two Very Different Perspectives of Learning

Science educators, language development experts and district administrators formed the small professional development team that would design and implement this newly conceived Science/Language PD program. As the professional development team approached the design of a blended program, we entered the process with different philosophies around teaching and learning. Science educators were using a modified version of Bybee's (1997) 5E lesson design (i.e., engage, explore, explain, elaborate, and evaluate) as the lesson-planning template. The 5E design was modified to include a concept column for each stage to illustrate the development of a science concept from students' prior knowledge to the learning goal of the lesson sequence (DiRanna et al. 2009). The science lesson template emphasized conceptual understanding, hands-on activities, and student interaction. Lessons began with the elicitation of students' prior knowledge of a concept and then provided a series of experiences that would allow students to build on that initial understanding. Although there were specific points in each lesson where students discussed their thinking with peers and their teacher, vocabulary and specific language functions and forms were not a focus of the lesson planning. On the other hand, ELD educators traditionally focused lessons on making the language of instruction (oral and written) accessible to the learner through the use of specific forms (e.g., grammatical features or word usage such as adjectives) and functions (i.e., the task or purpose, such as compare) of language. English language development often required the use of explicit instruction, modeling, and scaffolding by the teacher (Duffy 2002). Language forms and functions were often scaffolded with predetermined sentence frames that students used to build language. Sentence frames were used to provide the necessary support for students to generate sentences and express their thinking as students often possess vocabulary specific to the content but lack the words or phrases necessary to construct sentences. This involved the pre-teaching of specific grammatical structures and vocabulary prior to their use in a cognitive task. Although language instruction was often embedded in content-based lessons, conceptual understanding was not emphasized. The goal is the development of English language skills (Echevarria et al. 2008).

Overall, the science education philosophy was grounded in inquiry instruction where concepts and language unfold out of student-centered learning experiences, while the ELD philosophy

relied more on highly-facilitated instruction where the teacher frames, directs and monitors student language use, accommodating for varied English language proficiency levels. However, despite this clear distinction, common ground emerged. From our initial discussions we came to understand that there were some important areas of overlap in our instructional philosophies that would make the blending of science and language particularly powerful in elementary classrooms. We found common ground on three ideas:

1. Science processes and thinking skills mirrored functional purposes for using language (i.e., describing, comparing, citing information). "Doing science" utilized many of the formal reasons we use language and this connection could provide an authentic context for both inquiry and language development.
2. Science content could provide a highly-contextualized setting for language development. The realia was inherently provided through the rich, genuine natural setting of science.
3. Although students may not be proficient in English, they could still process science content at a high level, through complex thinking processes. As such, the science should not be simplified in an attempt to simplify language and could provide opportunities for students to engage in complex critical thinking.

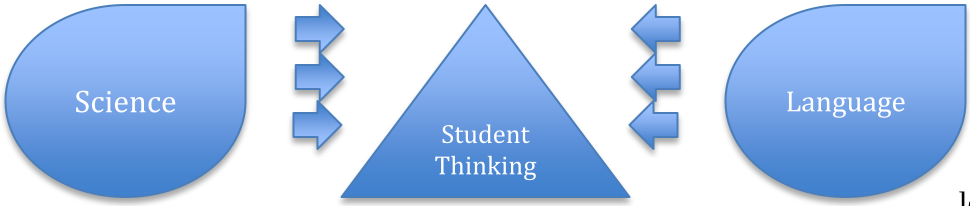
Initial PD design: Complementary yet Distinct Components

In the first year of the program, we considered language and science to be complementary, but separate pieces and our PD design reflected this perspective. Our two-week institute rolled out as two separate one-week programs. In the first week, teachers experienced both science content and pedagogy sessions. The second week, teachers learned about second language acquisition theories and strategies. These weeks where not planned nor conducted collaboratively except for one session that asked teachers to consider the connection between language and science instruction.

Teachers were first asked to identify elements necessary for quality science and to write these on individual post-it notes. Next, they were asked to identify elements necessary for quality English language development in a similar manner. Finally, they were asked to write new ideas on post-it notes or move existing ones for elements necessary for both quality science and ELD instruction (an overlap category). Most teachers did not create new elements but rather placed the majority of the elements in an overlap category. Elements traditionally associated with language instruction, such as front-loading vocabulary, think-alouds, and the use of realia, were seen as essential to both areas. The most commonly cited element was the use of hands-on materials/realia that provide a real-world context and are essential for language learning but also science knowledge. Teachers also placed elements more commonly associated with science applicable to both areas as well. Activating prior knowledge, student discussion, and evaluation, all essential elements of the 5E lesson format, frequently were placed in the overlap category. Many participants expressed excitement about the idea of teaching language through science. Participants often stated that in the past, they didn't really have time to teach science and saw the merging of the two domains as the opportunity finally to provide their students with access to this content area. What we quickly came to realize that what took us weeks to conceptualize, was an understanding easily grasped and adopted by teachers working in classrooms. Finally, almost every participant expressed the same desire: time to practice and plan for this integration at their

school site. The time for this would come during the academic year with a series of three, two-day lesson study rounds using the first draft of a blended 5E science and language lesson design.

Figure 2: Initial Perspective on the Relationship between Science and Language



Initially, the science/ELD lesson template was not a blend, but rather a compilation of everything included in both science and ELD lessons. This was a reflection of our current perspective on the relationship between language and science: the components were complementary but discrete. The result was a document that teachers found overwhelming to teach from and an impossible model for their own lessons. Although the language component focused on the vocabulary found in the science lesson and the science lessons were designed around context-rich experiences, the science did not truly support language development and the focused ELD instruction impeded the development of scientific understanding. Included in the design were prompts for language input (teacher) and output (student), modified according to English proficiency levels. However, these prompts were external to the 5E lesson, not integrated in a way that strengthened either the science or the language. Within the 5E science lesson were science activities and prompts, but, in practice, these activities often included ‘‘watered-down’’ content in an attempt to address the beginning English skills of the students. In addition, we lacked a clear protocol for when to focus on content and when to focus on language and failed in our attempt to serve two masters simultaneously. Due to this lack of clarity, as well as the overwhelming nature of the document, teachers tended to either focus on language and ignore the science or focus on the science and ignore the language development in their planning regardless of what the template included. Thus, although we could see the overlap between scientific processes and language functions, we found that an additive approach to creating the blend was unable to produce the level of student learning we had hoped. Clearly teaching ELD with science needed a different conceptualization than simply teaching ELD and science at the same time.

Second Phase of PD Design: Moving Towards a Blended Approach

We realized that our approach needed to be true to two very important priorities, putting student thinking first and making language development authentic. The new approach required that science be planned first before any considerations for which language forms and functions would also be taught within the lesson. This change was aligned with our primary goals and was also important for several pragmatic reasons: (a) the science content must be accurate and appropriate for the grade-level in order for the necessary language to emerge from students' thinking; (b) language can get in the way of the thinking, if it is artificially imposed on the content; and (c) as teachers discuss and collaboratively plan their science lessons, natural conversations about the content emerge as they design teacher questioning and predict student responses; the language during these conversations can be used to guide decisions about which language forms and functions become the ELD focus of the lesson.

Science was now seen as the necessary first consideration and structural center of the lessons. While we still saw language and science as complementary components, we now understood that the science would need to drive the language use. This shift in focus necessitated additional lesson plan features that would support teachers in their efforts to blend the ELD components more seamlessly with the science. As a 5E lesson unfolds, students engage in different levels of scientific thinking in each stage, providing students with context-rich opportunities to practice different language functions. Thus, a language function column was added to the lesson template to allow teachers to prethink what language functions would naturally fall out of the inquiry and require support. In addition, the input/output frames were more specific to the language or activity at each stage in the lesson. For example, if students were asked to recall information about rocks in the engage stage, but to compare and contrast properties of rocks in the explore stage, appropriate teacher prompts and student frames were designed in each section. This allowed for more specific language support, making it easier for teachers to engage students with limited English skills in more scientifically-rich conversations and activities. The input/output portions of an ELD lesson were embedded into the 5E design in the ‘‘teacher does’’ column and student sentence frames were moved to the ‘‘student does’’ column. Within these columns, headings were provided to focus teachers on accommodating students’ language development according to the varied English proficiency levels in their classrooms.

Vocabulary was another area of debate. Should vocabulary be introduced once an understanding of the concept had been developed or should it be described and clarified prior to any related investigation? Theoretical frameworks from linguistics suggest that you cannot use a word if you do not understand a word, while science’s constructivist theories view the understanding of an idea, which can be expressed as specific term, as constructed via personal experience by the learner. Eventually, it was decided that vocabulary would need to be carefully analyzed to determine which terms should be taught prior to the lesson (front-loaded) and which would fold out of the lesson itself (embedded). Words that might be front-loaded are words that students need to discuss and describe materials that are manipulated and described during exploration. These are words that one might expect students who are proficient in English to know and be able to use (e.g., above, round, blue). Frontloaded words would be taught in a more traditional ELD lesson prior to the science lesson. However, within the science lesson, students can practice the authentic use of these words during the science/ELD blended lesson and teachers are able to assess and monitor their use. Embedded words are those that can be developed through scientific exploration (e.g., sedimentary rock, liquid, precipitation). These words would be introduced during the lesson (teacher input) once students have experiences related to the scientific concept being explored, providing students rich opportunities for practicing and using the new language (student output) in a meaningful context. Vocabulary, along with specific language functions and forms, would need to be carefully considered for what, when and how they would be used. Which new words would be embedded in the lesson and which new words would be front-loaded (pre-taught) would be based on the instructional goals of the lesson.

Figure 3: Revised Perspective on the Relationship between Science and Language

While we knew that students are often engaged and excited during inquiry science experiences, we did not fully appreciate how this excitement would create in students the desire to share their ideas in a second language. Teachers, school administrators and staff all reported a noticeable increase in both oral and written English, but the surge in oral language use surprised even our harshest critics. Teachers were noticeably elated as they describe changes in their students. ‘‘It is much more exciting. So kids are willing to talk more, in English’’ (Teacher 2, Interview 1). ‘‘You should see the vocabulary they [students] use now, ‘we predicted today, we did some observations’’ (Principal 2, Interview 1). This increase in English use extended beyond science and beyond the classroom. Principals and teachers from multiple school sites described an increase in English use in other content areas and in non-classroom settings such as recess or in the office when speaking to administrators and support staff, who were capable of and used to communicating with students in their native language. However, this excitement occurred around authentic science experiences where students were engaged in "doing" science as well as talking about scientific ideas. Student excitement was highest and sustained when they had opportunities to "act like a scientist" while exploring complex and thought-provoking tasks.

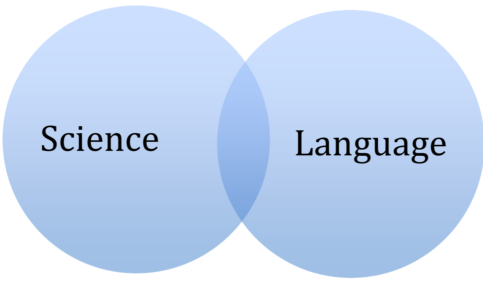
Our teachers began to describe shifts in their thinking about what a child with limited English is capable of learning, both in terms of content and language. ‘‘Even my low EL learners can verbalize these [science] things. You have to expect them to because sometimes it is just the language and not that they aren't thinking these things in their minds’’ (Teacher 9, Interview 1). Teachers often commented on the belief that their students can have a good understanding of the science, but be limited in their ability to express that thinking by their language ability. In other words, a limited student response might represent limited English skills rather than limited conceptual understanding or ability. It became clear that providing EL students' opportunities for critical thinking and analysis was changing teachers' expectations of these students. We began to understand that focusing on student thinking and the language needed to develop and communicate that thinking was central to the professional development program and creating equitable science access.

Third Phase of the PD Design: Places for Natural Language

In the final phase of the program, the connection between language and science became clearer for both the PD design and the blended lesson design. Initially, science and ELD PD sessions were planned and conducted separately. Midway through the project we began to use the content session to provide context that was used in the ELD sessions. Science content sessions were designed to provide teachers science-learning experiences related to the content they taught. However, these sessions were designed at an adult level and focused on science processes as well

as science content. While our ELD experts designed specific PD sessions, they observed the science sessions and integrated this science content into their ELD sessions, thereby modeling the process for creating blended learning experiences we had come to endorse.

Figure 4: Final Perspective on the Relationship between Science and Language



The blended lesson design also developed further in this last phase of the program. Initially, each phase of the 5E had specific linguistic scaffolds to support students' use of English. However, in this final phase, room for natural language was created within the blended lesson design. Initially, we thought it was necessary for language functions and frames to be identified in each phase of the 5E lesson design. However, as teachers developed their expertise and students were exposed to quality science instruction, we began to see the value in allowing students more freedom and liberty in how they communicated their thinking. In order to capitalize on prior knowledge and student enthusiasm, it was decided that students should be able to use language of their own choosing in the initial phases of the lesson. In the final phase of the program, we removed the language frames in the first phase (engage) and often in the second (explore) to allow more natural language use while students activate their prior knowledge and make sense of new science ideas. The formal ELD components are still part of the later phases (explain and elaborate) of the in order to support, rather than impede, student thinking.

Final Thoughts

This program removed a district's established and widely used ELD curriculum in favor of a novel approach to both elementary science instruction and English language development. In so doing we essentially ''stole'' instructional minutes from ELD to make room for science, a subject that, prior to our project, was rarely taught. We would have considered our project a success if participating students simply continued to develop their English language skills at a rate similar to those of students that used the state-adopted ELD program; we hoped the data might show that including instructional minutes for science instruction would ''do no harm'' and therefore restricting EL students' access to science was unnecessary. Instead, results from student assessment analysis indicate that the English language proficiency of students in the blended program, when compared to students participating in the traditional ELD program, actually improved. Although gains were modest, improvement was seen across multiple indicators (CST exam, CELDT scores, as well as teacher and principal interviews reported earlier) and through different means of data analysis (overall proficiency, sub-skills, multiple years of treatment). In particular, participation in the blended program appears to have a positive affect on students' oral language development (i.e., listening and speaking).

The results indicate that one of the program strengths was improving EL students' oral language, listening and speaking. This may be a direct result of the blended lesson design's focus on creating opportunities for students to work collaboratively, discussing and debating their ideas with evidence from their investigations. Student-to-student dialogue is a major component of the blended lesson design, as it is a central component of the scientific enterprise. We suggest that students must be allowed to explore new science concepts and then explain their current thinking about those concepts using manipulatives and other realia. Teachers should provide language scaffolds within their questioning strategies and provide students with leveled language frames to facilitate new concept understanding, but these carefully crafted language supports should not interfere with the scientific inquiry central to the construction of new scientific knowledge. Vocabulary essential to the inquiry (hard, blue, soft) is frontloaded and language frames are provided, but these are designed to support authentic scientific inquiry and maintain the central role of student thinking to instruction. This program did more than replace science topics for the existing topics in the ELD instructional materials. The blended 5E lessons became the center of instruction and blended both science content and science processes with ELD strategies.

The blend of inquiry science and language development requires a significant level of skill and knowledge. Teachers need to understand the science well as well as posses skill at both inquiry and second language acquisition. Teachers' decisions as to which terms and language functions should be front-loaded or scaffolded greatly depends on the content of the lesson and the sequence of that content within the overall flow of ideas throughout the unit or year. Without an understanding of science specific pedagogical content knowledge (PCK), teachers can in advertently remove the inquiry out of the science in an attempt to scaffold the language. Which language forms or functions are necessary for students to fully engage in the science learning and which would stifle their explorations are decisions best made by the teacher who not only possesses great knowledge of second language development and a varied repertoire of strategies, but also commands a deep understanding of science content. While teachers were able to develop this requisite knowledge and skill over the three year PD program, we came to greatly respect our teachers' understanding about the age of students they teach.

How can PD designs capitalize on the expertise that teachers bring to PD experiences?

The major conceptual shifts in our project came from honest and sometimes difficult dialogue with colleagues from a different field in education. Should we reach out more often for these types of collaborations? How might inviting in other perspectives to our conversations benefit this work?

The balance between providing freedom to explore and providing scaffolds for language is subtle and nuanced. What PD elements are necessary to foster an understanding of this complexity?

The PD design was developed around previous standards and accountability systems that focused on low-level tasks and facts. Given the adoption of CCSS and NGSS, how can this program utilize the shift in focus to critical thinking and application of knowledge?

Appendix: Project Background

The California Post-secondary Education Commission supported this project through the Improving Teacher Quality grants #07-420 and #08-501.

Project Design Team
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Context
This project was supported by the California Post Secondary Education Commission's Improving Teacher Quality grants. The four-year project was conducted in coordination with a large urban school district in California. The district serves a culturally and linguistically diverse population. Fifty-seven percent of students are English Language Learners (California Department of Education 2009). Eighty-one percent of the students qualify for free or reduced-price meals and the district is identified as a ''High Need District'' based on the percentage of families living in poverty (US Census Bureau 2005). An analysis of state testing data from the 2007 school year indicated that a majority of all students were failing to achieve adequate academic progress in Language Arts, Mathematics, and English acquisition.

Professional Development Plan
A professional development team comprised of district personnel, higher education faculty, and members of a state-wide professional development organization collaborated to assist the three school principals, sixty elementary teachers and over 2,000 students who participated in the project. Each summer for 4 years, teachers participated in intensive 2-week long professional development institutes that focused on a functional linguistic approach to ELD and emphasized teachers' science content and pedagogy. In addition to these summer institutes, teachers participated in site-based lesson study teams, called Teacher Learning Collaboratives (DiRanna et al. 2009) held throughout the year. The lesson study sessions were supported by the blended lesson template (Gomez-Zwiep et al. 2011) and focused on the collaborative design, teaching, and evaluation of science and ELD blended lessons.

The program utilized teacher-leaders who had received additional training to develop their mastery in science teaching, language development, and group facilitation. Teacher-leaders were invited from participating schools at the onset of the program. Teacher leaders eventually facilitated small group lesson study teams throughout the school year and workshops sessions during the summer institute. However, since their training began with the program's inception, the teacher-leaders shadowed and were coached by the program leads for at least one year before facilitating on their own. Teaching Learning Collaborative (TLC) strategy was used to expand the skills of K-2 teachers developed during the summer institute. Within the TLC, teachers work collaboratively to plan, teach and reflect on a lesson using a modified 5E lesson design. In grade-level teams, teachers participate in three cycles of the TLC process each school year. During TLCs, guided by a facilitator and/or teacher-leaders, teachers work collaboratively in grade-level

teams to write a lesson plan. During this planning, teachers are guided to consider both science and language development objectives. The lesson is collaboratively taught by the team, followed by a debriefing of the effectiveness of the lesson evaluated by evidence collected during the delivery of the lesson. Teams analyze student work and the facilitator's transcription notes of the lesson for indicators of the relationship between teacher decisions in the lesson plan and student understanding. The lesson is then redesigned, based on evidence from the classroom, and taught to another group of students collaboratively by the same team of teachers. The process of looking at student work is repeated and the lesson is further refined.

Quantitative Findings: Program Impact on Student Achievement.

Student achievement in English Language Arts was measured using scores from two state mandated assessments: the California English Language Development Test (CELDT) and the California Standards Test (CST) in English Language Arts (ELA). Scores on the CELDT and the language arts component of the CST were obtained in order to determine if program participation is related to increased student language development. Student science achievement was measured using the Science CST as well as an assessment developed by WestEd. The number of students in the sample varied depending on the number of students who were present and completed the assessment each year. However, all students at the three treatment and two comparison schools with a valid score on these assessments were included in the sample.

Participating teachers' students were measured against a non-participating comparison group from similar schools within the district. The comparison schools were selected based on similar student demographics (socio economic status, ethnicities, % of ELLs) and previous performance on the CST's. In the analysis of student achievement data, a response variable of mean improvement from a baseline year was used. Baseline was determined by the year a student started at the school site. Thus there is not one baseline, but rather multiple ones corresponding with the students' arrival at the site (when they began the program). This method provided a richer sample for analysis than using a single baseline for analysis such as when the program began (2007-2008), allowing all students who had a score on any measure to be included. For example, for a 1st grader who began in the school year 2006-2007 the analysis followed the improvement from 2007-2008 (Year 1 improvement); 2008-2009 (Year 2 improvement); 2009-2010 (Year 3 improvement) and 2010-2011 (Year 4 improvement). Since the analysis focused on the progression of students in the K-5 grades, if a student began as a 3rd grader the maximum number of improvements is 2 years. Since the analysis used student proficiency levels, an ordinal variable, non-parametric statistics were used. Group statistics and Mann–Whitney U tests were performed on CST and CELDT data to compare differences between the comparison and treatment schools. A Bonferroni correction was used to help reduce the overall type 1 error rate to 5 %. Unpaired T tests were used to compare mean scores on the WestEd science measure.

Table 2 All students CELDT student performance M–W U

	U	*df*	Mean difference	Sig (2-tailed)
Year 1 overall	4.226	2,321	0.166	0.000*
Year 2 overall	5.205	1,533	0.262	0.000*
Year 3 overall	5.134	860	0.364	0.000*
Year 4 overall	5.321	363	0.627	0.000*
Year 1 listening	2.563	2,320	0.120	0.10*
Year 2 listening	5.475	1,532	0.353	0.000*
Year 3 listening	3.692	629	0.375	0.000*
Year 4 listening	4.433	363	0.538	0.000*
Year 1 speaking	4.210	2,320	0.187	0.000*
Year 2 speaking	4.527	1,532	0.270	0.000*
Year 3 speaking	6.231	860	0.526	0.000*
Year 4 speaking	5.075	301	0.628	0.000*
Year 1 reading	1.374	1,248	0.086	0.170
Year 2 reading	1.866	543	0.060	0.060
Year 3 reading	0.090	258	0.012	0.928
Year 1 writing	1.978	1,248	0.122	0.048*
Year 2 writing	0.107	543	0.008	0.915
Year 3 writing	−0.554	222	−0.080	0.580

* Indicates a *p* value of .05 or below

Students who received the blended science/ELD instruction had small yet significant gains in their ELD compared to their comparison schools counterparts, as measured by the CELDT exam (Table 2). This was true for students with all years (1, 2, 3 and 4) of treatment (U = 4.226, U = 5.205, U = 5.134 and U = 5.321, respectively and p = 0.000 for all years). However, the overall CELDT score combines all sub-skill scores into one score, providing a single picture of a student's English language proficiency. It is possible to have a score in a sub-skill that is lower or higher than the overall score level. For example, a student might score at intermediate fluency overall but score early intermediate on the speaking sub-skill. Therefore, improvement in each sub-skill was also analyzed.

Similar to the overall score, there were small yet significant differences between groups on the CELDT sub-skills for listening and speaking. Students in the blended program had statistically significant higher means across all levels of treatment in the area of listening (U = 2.563, p = 0.10; U = 5.475, p = 0.000; U = 3.692, p = 0.000 and U = 4.33, p = 0.000 for treatment of 1–4 years respectively). A similar trend was found for the students' speaking CELDT scores (U = 4.210, p = 0.000; U = 4.527, p = 0.000; U = 6.231, p = 0.000 and U = 5.738p = 0.000 for treatment of 1–4 years respectively). However, the trend did not generally continue for the sub-skills of reading and writing. There was only one instance when students in the blended program had higher gains than the control students and that was in the area of writing for students with one year of treatment (U = 1.978, p = 0.048). Data did not exist for Year 4 reading and writing improvement, as these measures are not usually given to students below 2nd grade. There were no other instances of significant differences between groups for the reading and writing measures.

Table 3 CST ELA group statistics

	Group	N	Mean	SD
Year 1 improvement	Treatment	2,122	−0.07	0.841
	Control	1,225	−0.21	0.884
Year 2 improvement	Treatment	1,470	0.28	0.863
	Control	813	0.17	0.906
Year 3 improvement	Treatment	962	0.20	0.952
	Control	479	0.16	0.885
Year 4 improvement	Treatment	532	0.21	0.964
	Control	244	0.06	0.882

Based on the means of the comparison and treatment groups (Table 4), across all grades and all year improvements students who participated in the blended program demonstrated small increases in English Language Arts performance at a higher rate than those students who were taught with the traditional ELD curriculum; the mean is consistently higher for the treatment group than the control group (positive mean difference). For students who received 3 years of the blended program, this increase was not statistically significant. However, there are statistically significant improvements in Year 1, 2 and 4 ($p =$ 0.000, 0.004, and 0.040 respectively.).

Table 4 CST ELA M–W U Test results

	Mean difference	U statistic	*p* value
Year 1 improvement	0.147	4.775	0.000*
Year 2 improvement	0.112	2.880	0.004*
Year 3 improvement	0.037	0.724	0.469
Year 4 improvement	0.149	2.058	0.040*

Table 5 5th grade CST Science exam group statistics

	Group	N	Mean	SD
CST Science Baseline	Treatment	287	2.92	1.065
	Control	256	2.79	1.141
Year 1 CST Science (4th grade)	Treatment	302	2.94	1.166
	Control	244	2.82	1.074
Year 2 CST Science (3rd and 4th grade)	Treatment	242	3.02	1.093
	Control	242	2.60	1.232

Thus unlike the CST ELA data, where proficiency levels were used, the analysis of science achievement does not include growth over multiple years, but only performance in each year. Yet, the CST Science does provide some useful data. Analysis shows no significant difference in the baseline year or after 1 year of program between students in the blended program and students in the traditional program (Table 6). However, students who were in the program for both 3rd and 4th grade had significantly higher means than students in the traditional programs ($U = 3.981$, $p = 0.000$). It should be noted that although science instruction is often under emphasized in the elementary grades, some degree of science instruction is common in the 5th grade and, to a lesser extent, the 4th grade due to state testing.

Initial BLENDED LESSON DESIGN Example

Learning Sequence Concept: There are different types of biomes.

Language Objective: Identifying and describing.

Science Standard: Life Science 3b- Examples of diverse life forms in different biomes: Oceans, deserts, tundra, forest, grasslands, wetlands and their interactions.

5E	Teacher Does	Student Does ~ Language Proficiency Levels			Science Concept/ Language Function
		Low	**Med**	**High**	
Engage	You will now watch a Power Point on Animals and Biomes. PowerPoint Ice Breaker; Animals/ 6 biomes. Teacher introduces posters to the students. Act1- Name that biome! You are now going to walk around and match the biome name to the poster. -Have six posters of different biomes -Tell students: "Based on what you see in the poster match the name with the biome." Teacher will name the biomes whole group charting the names. Names will be on Field observation sheet	Low- Can you name the biome? Match the name to the biome. High- Can you tell me the names of the biomes? ESR: Oceans, deserts, tundra, forest, grasslands and wetlands. Students walk with their Field Observation Sheets.			Each biome has a name. ELD Function- Identifying
Explore	Act 1- writing nouns Use Field Observation Sheet (FOS) to write down nouns that can be found in the pictures. Act 2- Use the FOS: Write adjectives describing nouns Use adjectives to describe the nouns that you have listed.	ESR: cactus, whale, kelp, fish, coral, sand, water, kelp, grass, lizard, snake, dunes, mountain, hill, ravine, animals, plants, water, feathers, eggs, furESR: green, blue, brown, etc... big, humungous, cold, wet, freezing, humid, dry, hot, eats, hunts, ...			Each biome unique characteristics. Each biome has animals that have the same needs and act in similar ways. Function: Describing
Explain	Act 3- Form two lines A/B. Take turns sharing out information observed during Gallery Walk. Will use FOS/Frames. Discuss with your partner some of the adjectives you used to describe them . What nouns and adjectives describe one of the biomes? What nouns and adjectives can be used to describe all of the biomes?	(Beg.) There is a _____. I see a ______. The____is_____.	(Med.) I observed that the ___ has ____. The ____ has ____. I notIced that the _ is _	(High) As I closely observe, the _____ has ____. I would describe the____ as ____.	Each biome has different characteristics. Each biome has animals that have the same needs and act in similar ways. Function: Describing
Extend	1. Apply to Geography- Students locate different biomes on a map. 2. Travelers and Talkers: Use experts to describe the biomes.				
Evaluate	"Describe your favorite biome and tell why it's your favorite. What living things are found there?" Use student samples to assess their knowledge of characteristics of biomes.	Write 3 sentences that describe the biome	Write 5 descriptive sentences describing your favorite biome.	Write descriptive paragraph…	

Vocabulary *Adaptation Biome Desert Ocean Wetland* *Forest Tundra* *Survival Characteristics Behavior/patterns* *Physical*	*Tiers 1&2 BICS: cactus / snakes & lizards / frogs & toads* *animal that hunts / animal that is hunted* *animal that eats only plants.. eats only meat.. eats plants & meat* *animal that lives off of dead animals / …with feathers and lay eggs* *water falls from the sky / animals that give birth to live young/ feed milk*	*Tier 3-CALP: succulent / reptiles / amphibians* *predator / prey* *herbivore / carnivore / omnivore* *scavenger / birds /mammal* *precipitation*

Revised Blended 5E/ELD lesson design example

Language Objective: Students will begin to speak with a few

Learning Sequence Concept: Matter can change back and forth from words or sentences. Students will use gestures to demonstrate one form to another. Matter changes form from a solid to a liquid.

<table>
<tr><th rowspan="2">5E</th><th rowspan="2">Teacher Says/Does</th><th colspan="3">Student Says/Does</th><th rowspan="2">Science Concept Language Function</th></tr>
<tr><th>Low</th><th>Med</th><th>High</th></tr>
<tr><td rowspan="3">Engage
10 - 15 min.</td><td rowspan="3">Introduction: Think about yesterday's lesson on Matter? How many different states were there?
What were they?
(Record student responses on board.)
Gallery Walk- Post objects & pictures related to matter (e.g., water, a ball, pieces of fabric, craft sticks, lemonade, syrup) around room.
(1 min rotations):
There are objects and pictures of matter posted around the room. Observe each picture and tell your partner what you observe.</td><td>Three
Solid, Liquid and Gas (with gestures and/or native language support)</td><td>There are 3 states

Solid, Liquid, and Gas</td><td>There are 3 different states of matter
The three states of matter are Solid, Liquid, and Gas.</td><td rowspan="3">Science
Observe solids and liquids. Solids and liquids have observable properties.

Language
Describing and Comparing</td></tr>
<tr><td colspan="3">Students walk in groups to each picture and describe what they see</td></tr>
<tr><td>One word answers or
Yo veo _____,</td><td>There is _____,
I see _____,
It is _____.</td><td>This feels _____ and looks _____.</td></tr>
</table>

Final 5E lesson Template – First Grade, science lesson after inclusion of language elements

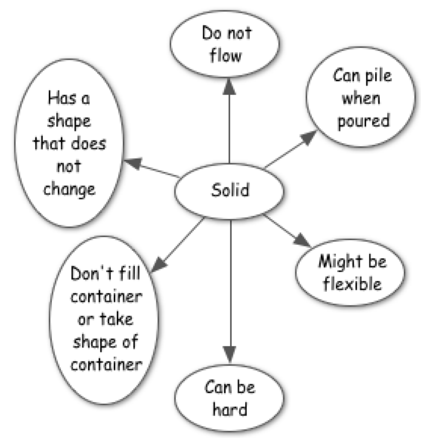
<table>
<tr><th>Concept/ Language</th><th>Teacher</th><th>Student</th></tr>
<tr><td><u>Engage</u>
Matter is the stuff around us and takes up space.
Describe</td><td>Last week we talked about matter. What do you guys remember about matter?</td><td>It is the stuff all around us.
It is anything you can put in a bag, even a really bag.
I am made of matter.<hr>Evaluate: students recall what matter is from previous lessons.</td></tr>
<tr><td><u>Explore</u>
Matter can be found as a solid, a liquid or a gas.

Compare and Contrast
Classify</td><td>Matter can be found in three common forms, or states.
Matter can be found as a solid like this pencil. Can anyone think of another example of a solid? Turn to your partner and tell them another example of a solid.
Matter can be found as a liquid like water in a glass. Can anyone think of another example of a liquid? Turn to your partner and tell them another example of a liquid.
Matter can be found as a gas like air. Can anyone think of another example of a gas? Turn to your partner and tell them another example of a gas.
Today I have brought different examples of matter (have sets of solids, liquids and gases in zip-lock baggies such as colored water, corn syrup, rubbing alcohol, erasers, sand, paperclips, wire, cloth, air and partially filled balloons). Real examples of matter or photos to be posted in room with name identified
Each group is going to get a set of bags containing several samples of matter. Your challenge is to try and sort the materials by state – put all the solids together, all the liquids together and all the gases together. If there are any samples that you are not sure of, put those in another pile.
Solid, Liquid and Gas should be posted clearly.
Materials inside the bags should stay inside the bags. DO NOT OPEN THEM.
Allow 10 minutes for students to sort samples</td><td>Our desks, a rock, a fork

Milk, juice, punch

The gas in a balloon

Students sort materials into groups representing each state. Students will probably have the sand or cloth in the uncertain pile.<hr>Evaluate: Students sort samples into appropriate groups</td></tr>
<tr><td><u>Explain</u>
Each state of matter can be described by unique characteristics.</td><td>On the board make a T-table with four columns<table><tr><td>Solids</td><td>Liquids</td><td>Gases</td><td>Unsure</td></tr><tr><td></td><td></td><td></td><td></td></tr></table>Call on students to holdup one of the samples,</td><td><table><tr><td>Solids</td><td>Liquids</td><td>Gases</td><td>Unsure</td></tr><tr><td>Eraser
Paperclip</td><td>Water
Syrup</td><td>Air</td><td>Sand
Cloth</td></tr></table></td></tr>
</table>

Compare and Contrast *Classify*	name it and suggest a category in which it should be placed. If everyone agrees on the identification and placement, write the name of the material in the table. If there is disagreement, list the item in the “unsure” category. Ask students to defend why the sort each material into a category. **Use a bubble graphic/map to clarify the properties of each state. As students describe a sample add the terms to the bubble map. If students do not know the correct term for a word like “flexible” or “pour” clarify for the class. Students should write down their own graphic organizer in their notebooks.** For a solid confirm that solids have a definite shape – they don’t flow or take up the shape of their container. For a liquid, confirm that liquids flow, take up the shape of their container and has a flat, level surface. For a gas, confirm that gases have no definite shape and fill their containers. Review the materials in the unsure category. In your notebook, answer the following question **What characteristics define the three states of matter (solid, liquid and gas)? Provide sentence frames for students to use.** **A solid is________.** **A solid is _____ and _____.** **A solid is_____ but not _________.** **______ is a solid.** **A liquid is________.** **A liquid is _____ and _____.** **A liquid is_____ but not _________.** **______ is a liquid.** **A gas is________.** **A gas is _____ and _____.** **A gas is_____ but not _________.** **______ is a gas.** **Matter can be a _____, ______ or ____.** **After students have had a chance to write their responses, tell them to read their descriptions about**	| | Rubbing Alcohol | | | Graphic organizer example. A similar one would be developed for liquids and gases.  Students correctly sort most of the samples and use the samples to develop definitions of each state: • Solids hold their shape, may be flexible, pile when poured. • Liquids have no definite shape, they do not fill their container, pour but don’t pile. • Gases take up the entire space of the container. Students share and discuss their descriptions. **Evaluate:** Students correctly sort and describe properties of solids, liquids and

	one state of matter to a peer. The peer will then read back their description of another state.	gases.
<u>**Elaborate**</u> The state of matter can be *identified* by its unique characteristics. *Classify and Justify*	Using the definitions of solid, liquid and gas you just created, find an example of each state of matter in the classroom.	Students find more examples of solids (crayons, books, pencil cases), examples of liquids (water, teacher's coffee) and examples gas (air in the room). **Evaluate:** Students correctly identify examples of solids, liquids and gases in the classroom.

Related Publications

Gomez-Zwiep, S. & Straits, W.J. (2010) Elementary teachers' perspectives on the integration of English as a Second Language and Science Instruction. *AccELLerate*, 2(3), pp. 5-7.

Gomez-Zwiep, S., Straits, W.J., Stone, K.R., Beltran, D., & Furtado, L. (2011). The Integration of English Language Development and Science Instruction in Elementary Classrooms. *Journal of Science Teacher Education*, 22, 769–785.

Shea, L.M., Shanahan, T.M., Gomez Zwiep, S. & Straits, W.J. (2013). Using Science as a Context for Language Learning: Impact and Implications from Two Professional Development Programs *Electronic Journal of Science Education*.

Gomez Zwiep, S. & Straits, W.J. (2014). Inquiry Science: The Gateway to English Language Proficiency. *Journal of Science Teacher Education*, 24, 1315-1331.

Gomez Zwiep, S., Straits, W.J. & Topps, J. (in press). Building Inquiry-Based Science Lessons: an Authentic Context for English Language Development. *Science and Children*

Additional References

Bybee, R. W. (1997). *Achieving scientific literacy from purposes to practices*. Portsmouth, NH:Heinemann.

DiRanna, K., Topps, J., Cerwin, K., & Gomez-Zwiep, S. (2009). Teaching learning collaborative: A process for supporting professional learning communities. In S. Mundry & K. E. Stiles (Eds.), *Professional learning communities for science teaching. Lessons from research and practice* (pp. 35–54). Arlington, VA: NSTA Press.

Duffy, G. G. (2002). The case for direct explanation of strategies. In C. C. Block & M. Pressley (Eds.), *Comprehension instruction: Research-based best practices* (pp. 28–41). New York, NY: Guilford Press.

Echevarria, J., Vogt, M., & Short, D. J. (2008). Making content comprehensible for English learners: *The SIOP model*. Boston, MA: Pearson.